

DOCUMENT RESUME

ED 153 985

95

SF 012 668

AUTHOR Agrawal, Piyush C.; And Others
 TITLE Metric Education: We Are Getting Ready for the Change.
 INSTITUTION Albany-Schoharie-Schenectady Board of Cooperative Educational Services, Albany, N.Y.
 SPONS AGENCY Office of Education (IEHW), Washington, D.C.
 PUE DATE 77
 GRANT CEG-007700843
 NOTE 92p.; Best copy available
 EDRS PRICE MF-\$0.83 HC-\$4.67 Plus Postage.
 DESCRIPTORS *Instructional Materials; *Metric System; Resource Guides; *Teacher Education; Teaching Guides

ABSTRACT

This handbook was prepared to aid teachers and teacher educators spread the messages "think metric" and "live metric." It includes a project description of a metric evaluation program and discussions of (1) an inservice training component; (2) a course outline for training programs; (3) the arguments for and against use of the metric system; (4) suggested competencies for students and teachers; (5) a workshop program; (6) support materials; (7) awareness components for parents and other adults; and (8) school district metrification policy. (MM)

 * Reproductions supplied by EDRS are the best that can be made *
 * from the original document. *

ED153985

ALBANY-SCHOHARIE-SCHENECTADY BOCES

PROJECT:
"METRIC EDUCATION:
WE ARE GETTING READY FOR THE CHANGE"

BEST COPY AVAILABLE

AN ELEMENTARY HANDBOOK ON
METRIC EDUCATION FOR TEAM LEADERS



PIYUSH C. AGRAWAL
Project Director

1977

REGIONAL PLANNING CENTER
1015 Watervliet-Shaker Road
Albany, New York 12205
(518) 456-9281

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

SP017 668

WRITERS/CONSULTANTS

Mr. Piyush C. Agrawal, Project Director

Mr. J. Craig Doherty, Principal
Mechanicville Public Schools
Mechanicville, New York 12118

Dr. Phillip Gibbons, Mathematics Supervisor
Bethlehem Central School District
Delmar, New York 12054

The preparation of this handbook was supported in part by the U.S. Office of Education, Department of Health, Education, and Welfare under the Grant #007700843. However, the opinions expressed herein do not necessarily reflect the position or policy of the U.S. Office of Education, and no official endorsement by the U.S. Office of Education should be inferred.

"THE WORLD HATES CHANGE, YET IT IS THE ONLY
THING THAT HAS BROUGHT PROGRESS."

*"While any intelligent child can learn and carry in his
mind the whole metric system in three lessons, and any
adult can master the same in one hour or less of serious
study, no man ever has, and probably no man ever will,
master the United States System of Weights and Measures."**

*Wells, William C., Scientific Monthly 4: 196-202; March
1917 quoted in U.S. Metric Study Interim Report: Education,
National Bureau of Standards, U.S. Department of Commerce,
July 1971, p. 91.

TABLE OF CONTENTS

	<u>Page</u>
Writers/Consultants.....	i
Quotations.....	ii
Foreword.....	iii
 1.0 PROJECT DESCRIPTION.....	 1
1.1 Introduction.....	2
1.2 Goals of the Project.....	3
1.3 Objectives of the Project: Phase I (July '77 - June '78).....	4
1.4 Benefits Expected.....	5
1.5 Short Description of the Project Activities.....	6
2.0 IN-SERVICE TEACHER TRAINING COMPONENT.....	7
2.1 Training Program.....	8
2.2 Leadership Role (Training Model).....	9
2.3 Features of the Training Model.....	10
3.0 COURSE OUTLINE FOR TRAINING PROGRAMS.....	13
3.1 Metric Awareness.....	14
3.2 Experiences with Metric Measurement.....	14
4.0 WHY METRIC?.....	15
4.1 Some Interesting Arguments: Metric vs. Customary....	16
4.2 A Puzzle: How Well Do You Think You Know Our System of Measurement?.....	19
4.3 Why We Should Use the Metric System?.....	20
5.0 SUGGESTED COMPETENCIES FOR TEACHERS.....	24
5.1 Suggested Competencies for Elementary Teachers in Metric System.....	25
5.2 Language of the Metric System.....	26
5.3 Key Terms.....	29

	<u>Page</u>
5.4 SI Metric System.....	30
5.5 Preference in the Choice of Units.....	32
6.0 SUGGESTED COMPETENCIES FOR STUDENTS.....	33
6.1 Framework for Organizing Student Competencies in Metric Measurement.....	34
6.2 Suggested Competencies for Elementary School Students	35
6.3 Organization of Student Competencies Through Head and Heart.....	45
6.4 Suggested Guidelines for Teaching Measurement with the Metric System.....	46
7.0 WORKSHOP PROGRAM.....	49
7.1 Suggested Schedule for Metric Education Workshops....	50
8.0 SUPPORT MATERIAL.....	52
8.1 Project Produced Material.....	53
8.2 Material from New York State Department of Education.	54
8.3 Some Other Sources.....	55
8.4 Introduction to Length.....	56
8.5 Introduction to Area.....	60
8.6 Introduction to Volume.....	64
8.7 Introduction to Capacity.....	68
8.8 Introduction to Mass.....	72
8.9 Introduction to Temperature.....	76
9.0 METRIC AWARENESS COMPONENT FOR PARENTS AND OTHER ADULTS..	80
Awareness Workshop Brochure (Sample).....	82
10.0 SCHOOL DISTRICT METRICATION POLICY.....	83
10.1 A Suggestion.....	84
10.2 Sample Guidelines for Metrification.....	84

11.0 APPENDICES

11.1 Module in Length

11.2 Module in Area

11.3 Module in Volume and Capacity

11.4 Module in Mass

11.5 Module in Temperature

FOREWORD

This handbook which is a product from the Project "Metric Education: We Are Getting Ready For The Change," has been prepared for the use of teachers and teacher-trainer team leaders. The basic strategy suggested in the handbook for team leaders training is that of "cooperative-inquiry" and, therefore, this handbook is in no way a prescription either in terms of organization and sequence of contents or in terms of methodology. The main purpose for its development has been to provide some of the substantive components to initiate inquiry within the "cooperative-inquiry group" so that participants may interact with each other, may analyze one another's teaching experience, and, also, may compare and develop new activities and experiments.

Parts of this handbook were developed and tried during the recent workshops conducted by the Project Director for the BOCES level team leaders. Participants of these workshops made a significant contribution in the development of this handbook.

It is expected that BOCES team leaders will use this handbook during workshops to be conducted for school district leaders, school building leaders, and for classroom teachers. During these workshops, the participants should be encouraged to bring in their own metric education experiences for the purpose of enlarging the scope of sample activities described, and to enrich the learning situation for the other participants.

Grateful acknowledgement must be made of the support this project has received from the State Education Department, especially from Mr. LeRoy Negus, Chairman, State Education Department Metric Committee. Also the cooperation of the following firms in offering 'gratis' material for use in the workshop is gratefully acknowledged and their contribution toward the success of the program is highly appreciated: Ohaus Scale Corporation, Florhaus Park, New Jersey; ENRICH Inc., Sunnyvale, California, and New England School Supply, Delmar, New York

Great appreciation must be expressed for the support staff of the Regional Planning Center which not only despises inefficiency but offers "service with a smile."

December 1977

Piyush C. Agrawal
Project Director

1.0 PROJECT DESCRIPTION

1.1 INTRODUCTION

Through the passage of the Metric Conversion Act of 1975, it was declared that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States, and therefore, it is now well established that the United States is to "go metric" as soon as possible. Efforts, from all quarters, are being made in the direction of preparing Americans for this changeover. Schools and teachers have an important role to play in this effort. Children need to be prepared as part of their regular educational program, so that they can use the metric system (SI) with ease and facility.

In August 1977, Governor Hugh Carey signed a bill to revise the Weights and Measures Law by adopting the metric system as the preferred system of measurement within the State of New York.

The Commissioner of Education of New York State has recommended predominant use of the metric system in schools by June 1980.

To bring about this change, teachers first need to be oriented in the metric system. The activities of this project, which is partially funded by the U.S.O.E. as one of 75 funded nationally, include a comprehensive plan to educate teachers, and through them the students and adults in 13 counties in northeastern New York State with the metric system.

1.2 GOALS OF THE PROJECT

- To train teacher-trainer teams, at three levels -- BOCES, school district and school building -- including instructional supervisory personnel.
- To train classroom teachers.
- To prepare and/or adapt instructional materials for training of teachers and for use in the classroom.
- To assist and monitor classroom "metric" instruction.
- To conduct "awareness programs" for the benefit of parents and other adults in the community.

1.3 OBJECTIVES OF THE PROJECT: PHASE I (JULY '77 - JUNE '78)¹

During the first year of the project, the activities will be directed at achieving the following objectives:

- To train five teams of team leaders, (one for each BOCES area) of educational personnel, including supervisory and instructional, who will teach the metric system of measurement through in-service education programs.
- To develop material and examine for possible modification the suitability of already existing material so that it can be used for team leaders training and in-service training of elementary school teachers.
- To provide technical assistance to school districts with a view to help them develop metric education programs in accordance with the suggestions made by the New York State Education Department.
- To train, through in-service programs, elementary school teachers, who then will be able to use and teach the revised metric system (SI).
- To develop, during these in-service training sessions, material for use in classrooms for the benefit of elementary school children.
- To provide technical assistance in developing material for school districts which are ready to start "community awareness" programs for the benefit of parents and other adults.
- To extend technical assistance to private and other non-public schools.

¹Phase II (July '78 - June '79) is planned to focus on Secondary Education.

1.4 BENEFITS EXPECTED

During the first year of the project, it is expected that about 150,000 people in the geographic area will be affected, directly or indirectly. The target population will be getting ready to use the metric system (SI) of measurement in their daily life.

The project's design focuses on establishing functional linkages among the various cadres of team leaders, classroom teachers, instructional supervisory staff, and the community. The in-service teacher training program lays heavy emphasis on the "multiplier effect" and, therefore, it is expected, that even after the project is phased out, the impact will still remain and the task of providing instruction in metric education will continue.

During the second year, another contingent of approximately 150,000 people (mostly secondary school teachers and students) will be affected.

Thus, the project will touch the life-style of about 300,000 people in this geographic area with a potential to affect even more.

1.5 SHORT DESCRIPTION OF THE PROJECT ACTIVITIES

With a view to derive maximum benefits in spite of modest funding and during the shortest possible time, the project is designed to spread the message of "think metric" and "live metric" among 150,000 people during its first year. To reach this goal, the project focuses on in-service teacher training. The teacher training program includes conducting workshops and developing and/or adapting suitable instructional material. A course outline for this training has been developed. After the teachers have been trained, the students will directly receive the benefits of the program. Simultaneously, parents and other adults in the community will be invited to participate in the metric education program. Thus, the project has four major foci:

- Teacher Training
- Development/Adaptation of Instructional Material
- Classroom Instruction
- Community Awareness

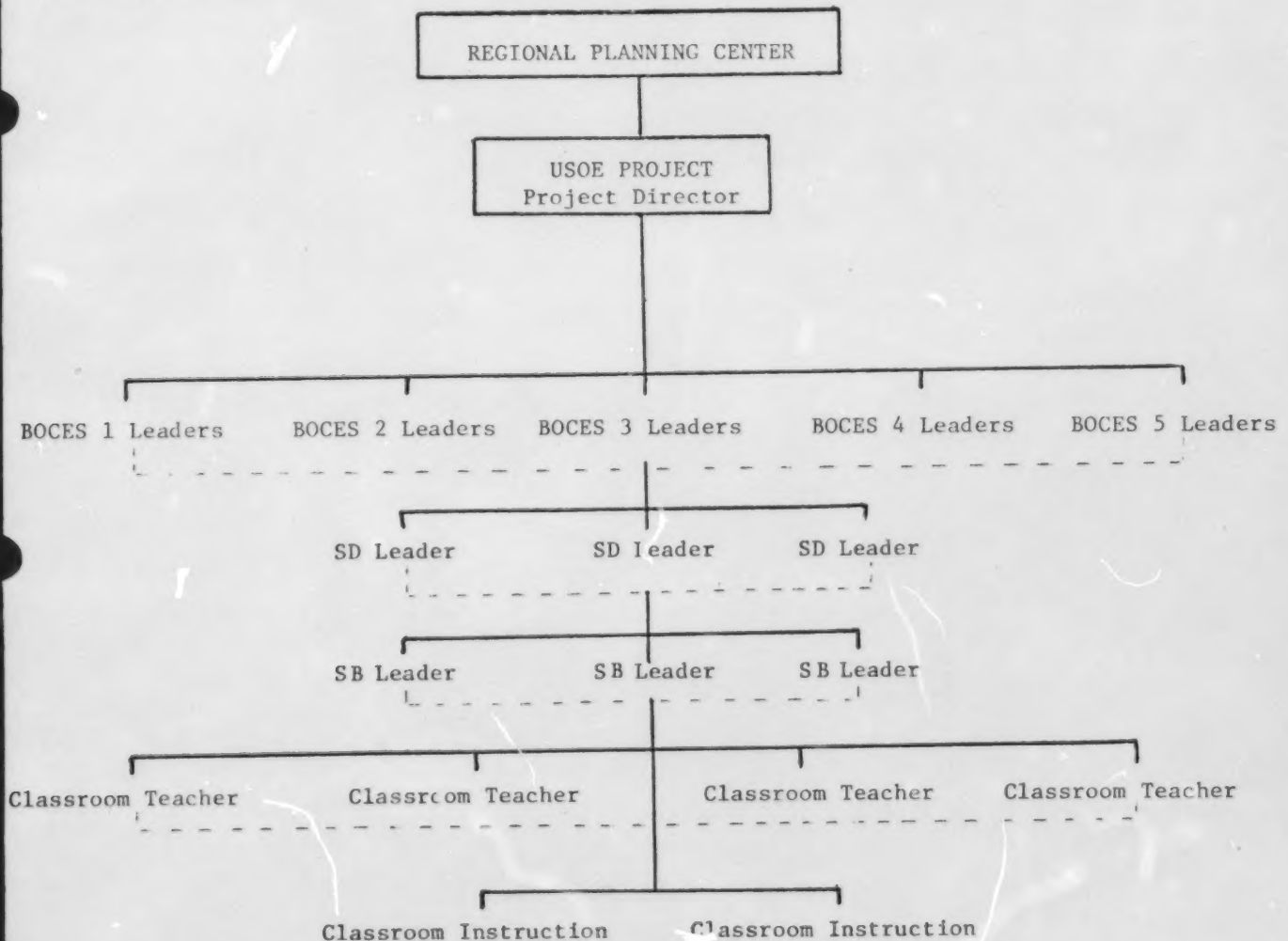
2.0 IN-SERVICE TEACHER TRAINING COMPONENT

2.1 TRAINING PROGRAM

- During the first phase of the project (1977-78) the emphasis will be on training first level (elementary school) personnel. One project director will train 15 team leaders. Collectively, they will train more than 80 leaders at the school district level, who in turn will train about 400 school building leaders. These building leaders will then train classroom teachers. Thus, it is anticipated that during the project period nearly all the elementary school teachers (approximately 5,000) in the target population will have the opportunity to be trained.
- Training sessions will be held only once a week for each group to minimize disruption of current school programs. This will allow the leaders time to practice new methods and try new material in the classrooms before they return for further instructions.
- During these sessions team leaders from the BOCES, in consultation with the leaders at the school district and school building level, will formulate plans for classroom implementation. Also, during these sessions, the project director will extend technical assistance in planning and classroom implementation.
- Subsequent to these sessions the project director and other team leaders will monitor the classroom activities of the program in 10 selected classrooms.

2.2 LEADERSHIP ROLE (TRAINING MODEL)

It is expected that BOCES leaders shall act as team leaders and will provide necessary guidance, material, and resources to district (SD) and school building (SB) leaders, and classroom teachers. Similarly, it is anticipated that district leaders will extend their assistance to building leaders and classroom teachers and that building leaders will help classroom teachers. Classroom teachers will implement the metric education programs in the classroom. This relationship among various cadres of leaders is shown below:



2.3 FEATURES OF THE TRAINING MODEL

2.3.1 Important Functions of the Leaders

The following roles and functions are anticipated for every leader under the activities of this project:

- Scholar: He controls structures for studying the school and for studying teaching and learning, so he can design and carry out educational experiments. He masters a range of teaching strategies derived from different views of learning, and more important than that controls techniques for developing and testing new ones.²
- Innovation: To be an innovator rather than a bureaucratic functionary, a leader needs to combine personal creativity with ability to work with others, to build educational settings in which innovation rather than imitation is the norm.
- Interaction: There are two most familiar and important interaction roles of the leader: interaction with students, and interaction with teachers. In classroom situations he identifies strategies for making instructional decisions which are tailored to the characteristics and needs of the students; whereas in the company of his colleagues, he shares analysis of teaching and learning situations, and thus controls techniques for designing continual small experiments of teaching and learning.
- Facilitator: In this capacity, the leader helps the learner to diagnose his needs for learning, to select from a range of strategies, tools and methods, those which will be most effective in assisting the learner in achieving his/her goal. This means that the leader is expected to have a broad repertoire of strategies for solving problems along with a wide knowledge of pertinent materials, resources, tools and methods. Considerable skill in interpersonal relations is also required.
- Institution-Builder: (Shaper of the School): In this capacity, he works with other faculty members, community representatives, students, and administrators to design educational programs and organizational structures. He monitors strategies for studying and designing curricular systems, and in accordance with the needs and demands of the system, offers and employs technical support system.

²Bruce R. Joyce. The Teacher-Innovator: A Program to Prepare Teachers (Washington, D.C.: Government Printing Office, 1969) pp. 16-17.

2.3.2 STRATEGY FOR TEAM LEADERS TRAINING

The basic teaching strategy in the program is "cooperative inquiry." Leaders will be organized into inquiry groups of about 10-12 members. The Project Director and consultants will help these groups to educate themselves. The substantive components will be designed and developed in advance to initiate inquiry within the inquiry-group. For feedback, the group will be organized into smaller teams of 3-4 members to interact with each other, to analyze one another's teaching experience, and to compare new activities and experiments.

2.3.3 ABC's OF GROUP LEADERSHIP³

* A leader is known by the action he gets,
* By the way he motivates - the pace that he sets,
* If you want to lead, you cannot wait,
* Get busy now and activate.

* Your knowledge is your power,
* So improve yourself by the hour,
* When from ignorance you've been freed,
* You'll have the confidence to lead.

* It isn't enough to set in motion
* A program that needs a lot of promotion.
* After the thousands of things you do --
* Finish the job by following through.

* People clamour
* "We want glamour"
* A leader wise
* will dramatize.

* For programs of vitality
* You need originality.
* If you want programs to live
* Make sure to use initiative.

* Develop people where they exist,
* In a friendly manner they will not resist.
* Encourage each person to do his best,
* And you'll win cooperation with interest and zest.

³ Source: ABC's of Group Leadership by Marion J. Betnum,
published by Leadership and Fund Raising Training Institute,
Beverly Hills, California.

3.0 COURSE OUTLINE FOR TRAINING PROGRAMS

3.0 COURSE OUTLINE FOR TRAINING PROGRAMS⁴

3.1 Metric Awareness

- History - A brief historical background on measurement including progress made in the implementation of the SI metric system at the local, state, national and international level.
- Advantages of the SI metric system:
 - The metric system is based on decimal numeration similar to the U.S. monetary system, and therefore, is easy to understand and use.
 - The coherence and simplicity of the metric system are factors that have contributed to its acceptance.
- Introduction to the SI metric units. Use of common SI metric units.

3.2 Experiences with Metric Measurement

- Activities similar to those in which students will be involved. The activities range from free exploration with a variety of materials to more structured exercises such as the following:
 - Measurement activities directly related to real world situations, direct comparisons, comparing non-standard units, comparison with SI units, choosing units of appropriate size for specific tasks;
 - Construction and use of simple measurement devices;
 - Games, puzzles and other problems to develop and reinforce the basic concepts and skills of measurement and to achieve proficiency in conversion techniques within the metric system.
- Processes around which measurement activities may be organized: language development, estimation, simple matching and comparisons, ordering, simple relationships, pictorial representations.
- Experiences which enable teachers to acquire a knowledge of the prefixes, symbols, and notation terminology used in the SI metric system.
- Experience in developing teaching strategies for teaching measurement using the metric system (SI).
- Opportunities to examine a variety of learning materials for measurement.
- Informal and formal diagnostic techniques that enable the teacher to determine the level of conceptual and skill readiness of students.
- Experiences that enable teachers to use a variety of community resources.

⁴ Based upon the recommendations and suggestions made by ICME (Interstate-Consortium in Metric Education) - a consortium of representatives from 28 states and territories of the U.S.

Tardif, Robert; and others: Interstate Consortium on Metric Education, Final Report, California State Department of Education, Sacramento, California, 1975, 28 pages.

4.0 WHY METRIC ?

4.1 SOME INTERESTING ARGUMENTS: METRIC VS. CUSTOMARY⁵

PRC-METRIC:

PRO-CUSTOMARY:

1. Which system makes calculations easier?

- "It's easy to compute with metric units. All you have to do in many cases is add a zero or move a decimal point."
- "There are only a few units and the relationships among them are pretty simple."
- "The International Metric System has different terms for mass (the kilogram) and force (the newton) eliminating a confusion between mass and force that has perplexed generations of students."

• "Practically speaking, it's often easier to do simple arithmetic in your head with Customary units, because both the duodecimal and binary bases are handier."

• "If we are going to change, let's look for some combination of number bases better than either decimal or duodecimal."

• "This is an age of computers. If you have a really complicated problem, the machine can handle any units, and so there is no reason to change to a decimal base."

2. Which system is personally more convenient?

- "The metric system has a more fundamental relationship to human anatomy. It is based on the number 10; we have 10 fingers; and from antiquity people have learned to count on their fingers."

• "Customary units of length suggest a close relationship to human measurements, e.g. the foot and the yard or pace."

• "Even some scientists argue that units like the candela are artificial."

• "The purported logic of metric unit names is violated by the use of the kilogram as the base unit of mass. Why not the gram?"

• "In the International Metric System the derived units with hard-to-remember names - such as the Pascal, the Siemens, the Weber, and the Tesla - are proliferating."

3. Problems and opportunities within the United States.

- "Experience has shown that conversions of this kind turn out to be much easier and less costly than anticipated."
- "Metric is easier to learn; thus schools would have extra time to teach some of the new subjects now being introduced into the curricula."

• "Changing would cause confusion. Consumers would not know whether they were getting their money's worth for things sold by length, weight or volume. For a while you might not understand what you read in the newspaper or heard on television."

• "Many companies would have to carry double inventories of spare parts during the transition period."

⁵ Source:

A METRIC AMERICA, Report to the Congress, National Bureau of Standards, Washington, D.C. July 1971, pp. 36-43

PRO-METRIC:

PRO-CUSTOMARY:

3. Problems and opportunities. (continued)

- "Metric is easier to use and, therefore, engineers would save time and make fewer errors."
- "The necessities of conversion would offer opportunities: During adjustment to the new measurements, there would be a chance to clean house and eliminate many of the superfluous varieties of nuts and bolts, and other common goods.. Manufacturers' inventories might actually be reduced."
- "There would be an opportunity to improve the technical quality of building codes and other engineering standards. And schools would have an added reason to revamp textbooks and curricula." Conversion to metric could stimulate invention and innovation."
- "Small businesses and self-employed craftsmen would benefit from a coordinated conversion program. As it is, they are being left behind by some big firms that have the expert staffs."
- "Speaking a common measurement language, scientists, engineers, businessmen, educators, and government officials would communicate with one another more freely and with less risk of misunderstanding."
- "A changeover to the metric system would be a stimulus to the economy comparable to the space program."

4. The United States and the World.

- "We would fortify our position as a leader by joining the rest of the world in a common measurement system."
- "Travelers, traders, and all other U.S. citizens who have dealings abroad are handicapped to the extent that they are unfamiliar with the commonly accepted measurement language."

- "People would have to be re-trained. And during the re-training period they would be deprived of invaluable experience the intuitive feel for measurements on which craftsmen, mechanics, and engineers depend."
- "Dealing with unfamiliar quantities might result in safety hazards due to mistakes."
- "A coordinated conversion program even if largely voluntary, would be simply another government encroachment on free choice."
- "Conversion might be easy enough for big firms with engineering staffs and foreign trade departments. But small businesses would find it very difficult."
- "During transition the nation would be part metric and part Customary."

- "Let's not risk our industrial success with a measurement system promoted by countries that have not done as well technologically as the United States."
- "Going metric would open the way to imports from countries that do not make products to Customary specifications."

PRO-METRIC:

PRO-CUSTOMARY:

5. Implications for the Future

- | | |
|--|---|
| <ul style="list-style-type: none"> • "Though small in relation to the total economy, our exports are crucial to maintaining a favorable trade balance in an increasingly metric world." • "Our economy today, as never before, depends on trading raw materials, manufactured products, even technological ideas with countries that have changed to metric or committed themselves to do so. We put ourselves at a competitive disadvantage by using a measurement system different from that of the world market." • "We want to have our say in setting international standards of all sorts, especially those concerned with industrial products." • "Our military allies are either metric or committed to change to metric." | <ul style="list-style-type: none"> • "Our export trade is so small compared with our Gross National Product that the advantage of manufacturing according to metric standards would be insignificant." • "Within our borders the Customary system works all right. Foreign considerations do not warrant disrupting our trillion dollar economy." |
| <ul style="list-style-type: none"> • "The nation is already heading toward the metric system, although slowly and in an unorganized way. It will never cost less than it will right now. Postponing the decision to change transfers a greater burden to future generations of Americans." • "The costs and inconveniences of metric conversion would be temporary; they would stop at the end of the transition period. The benefits would continue indefinitely." | <ul style="list-style-type: none"> • "If we decide to go metric, we are likely to pick the wrong time. No one can guarantee what the economic conditions would be throughout the transition period. The measurement conversion might complicate all our problems." • "Even in good times the nation is faced with complex problems. Why add to them a troublesome change in measurement?" |

4.2 A PUZZLE: HOW WELL DO YOU THINK YOU KNOW OUR SYSTEM OF MEASUREMENT?

Did you know?

1. "What is heavier, a pound of gold or a pound of feathers?"

"They both weigh the same," answers the bright child in whom we have carefully nurtured logical thinking.

"Wrong!" we reply. "A pound of feathers is determined by avoirdupois weight and measures 7,000 grains. A pound of gold is determined by troy weight and measures 5,760 grains. Thus, a pound of feathers is heavier.

"Clear?"

2. "Let us try once more. What is heavier, an ounce of gold or an ounce of feathers?"

"An ounce of feathers?"

"Wrong!"

"They both weigh the same?"

"Wrong again! A pound of gold consists of 12 ounces because it is determined by troy weight. Therefore, an ounce of gold is equal to 480 grains. But there are 16 ounces in an avoirdupois pound. Therefore, an ounce of feathers equals 437.5 grains."

3. Though a bushel generally represents 60 pounds avoirdupois, it is equal to only 48 pounds of barley, 32 pounds of oats, or 56 pounds of rye corn. And do not forget the regional differences. In Massachusetts a bushel of potatoes is 60 pounds, but only 56 pounds in North Carolina or West Virginia.
4. Similarly, a last (load) of herring was 12 kegs, but a last of gun powder was 24 kegs. A last of brick was 500 bricks, but a last of wool was 12 sacks.⁶

The list of questions could have been made much longer and more difficult by including references to rods, furlongs, square perches, poles, chains, cords, fathoms, cables, nautical miles, leagues, pecks, gills, drams, hogsheads, and barley corns.

5. See, what a barrel means!⁷

1 barrel of water = 55 United States gallons.

1 barrel of petroleum = 42 U.S. gallons.

1 barrel of beer = 31 U.S. gallons.

How inconsistent the "barrel" is?

⁶Gerardus Vervoost: "Inching Our Way Towards the Metric System." Instructive Teacher, April 1973.

⁷Helmer A. Rominger: Metrics: Measurement for Tomorrow. Collier Books, New York, 1972, p. 61.

4.3 WHY WE SHOULD USE THE METRIC SYSTEM?

SI is by far the most superior system of measurement and calculations yet derived. The following statements are given hereunder in its support:

1. The metric system is logical in concept.
2. It is extremely convenient to use. Computations are much simpler because of the uniform system of prefixes.
3. It provides greater speed in operation. Its decimal basis conforms to our numeration system.
4. It is easier to teach and easier to learn.
5. It is based upon an internationally accepted language. For example, the prefix kilo means 10^3 or 1 000 to all the people in the world. Similarly milli means 10^{-3} or 1/1 000. (But, in contrast, if an Englishman said a 'billion' he meant a 'million million' or 1 000 000 000 000 but if an American used the word a 'billion' he intended a 'thousand million' or 1 000 000 000. What a confusion! Is it not better to get rid of this confusion?)
6. The meter, which establishes the basis for the SI system can always be reproduced from national phenomenon and therefore is immune to destruction.
7. A common measurement language that is used by scientists, engineers, and industrial workers would improve communication and reduce barriers between different sections of society.
8. Much of the customary drill in fractions could be reduced.
9. Time saved due to teaching a simple SI system could be used for the introduction of valuable new materials.
10. Educational system would no longer be burdened with teaching two systems of measurement.
11. The "Costs" of not going metric: About 15 percent of the instructional time in mathematics is absorbed by drill in fractions and percent, time which might otherwise be gainfully used for introducing important new materials. It has been estimated that the costs of not going metric is the continuation of \$500 million waste of time each year.⁸

In addition to the above, there is the cost, in time and learning effort for science students and teachers, of learning and teaching the metric system as a second measurement language. Both students and teachers have virtually no use for metric measurement outside their classes, it rather tends to create a language barrier between science and the rest of the world of learning and living.

⁸From: U.S. Metric Study Interim Report: Education, National Bureau of Standards, Department of Commerce, Washington, D.C., July 1971, p. 11.

U.S. METRIC STUDY: A SUMMARY⁹

(Implications for Education)

Many times in the last two centuries, the Congress considered the merits of adopting the metric system as America's primary language of measurement. Each time, action was postponed, often because the metric system was not then in use by our major trading partners abroad. Now, with every other major nation converted to metric or committed to conversion, this obstacle has been removed.

The basis for the conclusion that the U.S. will eventually be metric lies in the findings of the Study (The U.S. Metric Study) that America is already metric in some respects; that we are becoming more so; and that the great majority of businessmen, educators and other informed participants in the Study reported that increased use of the metric system is in the best interests of America. They also believe that it is better for the nation to move to metric by plan rather than by no plan at all.

On the basis of all the factors that were considered, the Study concludes that it would be best for the nation to change to metric under a coordinated program that provides for flexibility and encourages the various sectors of society to deal with their particular problems voluntarily. Within this framework, these sectors would work out their own timetables and programs, dovetailing them with those of other sectors.

Developing a national program for change would require a great deal of forethought and discussion. But the Study finds that two major activities should be begun immediately, because they would be pivotal in preparing the nation for increased use of the metric system.

- The first is education. Every schoolchild should have the opportunity to become as conversant with the metric system as he is with our present measurement system.

- The second concerns international standards and increased affect on world trade.

While the majority of the American people are not well versed in the metric system, the Study shows that those who are informed about it tend to favor it. This demonstrates a need for public education to help all citizens to cope with the trend to metric.

⁹ *From: A Metric America: A decision whose time has come. Report to the Congress. National Bureau of Standards. Washington, D.C., July 1971, pp. xv - xvii.

PROGRESS TOWARD METRICATION

- 1790 President Washington, in his first message, reminded Congress that it was time to set our own standards of weights and measures. Jefferson, later proposed two plans. "But despite prodding from President Washington in two subsequent messages, neither plan was adopted."
- 1790 A metric system of measurement was developed by the Paris Academy of Science.
- 1821 John Quincy Adams submitted "Reports upon Weights and Measures." He deemed it wise "to contact both Britain and Spain before making any such radical change as adopting the metric system. Congress took no action on Adams' report.
- 1840 France passed a law in 1837 making it compulsory to use metric system of measurement throughout the country after January 1, 1840.
- 1866 Kasson Committee reported favorably on the use of metric system to the congress. Use of metric weights and measures was legalized.
- 1873 American Metriloical Society was founded to promote interest in the metric system.
- 1875 The International Bureau of weights and measures was set up.
- 1876 American Metric Bureau was founded in 1876.
- 1889 The U.S. received prototype meter bars and kilogram weights.
- 1893 The Secretary of the Treasury declared the new metric standards to be the nation's "fundamental Standards" of length and mass. Thus the U.S. became an officially metric nation.

The yard, the pound, and other customary units were defined as fractions of the standard metric units. The pound, and other customary units were defined as fractions of the standard units.

- 1896 A Bill Wins Then Dies: An attempt to convert the nation was made in 1896, and for a short while it appeared that it might succeed. Ardentlly supported by the Committee on Coinage, Weights and Measures, the bill passed the House by the bare margin of 119 and 117. But opponents forced a reconsideration and launched an attack stressing the difficulty of making a change. Foreseeing defeat, the Committee chairman had the bill sent back to his Committee, and there it died.
- 1916 The American Metric Association was formed with headquarters in New York.
- 1957 A U.S. Army regulation established the metric system as the basis for weaponry and related equipment.
- 1958 U.S. agreed to define the inch and the pound by the meter and the kilogram.

- 1960 The metric system was refined by the General Conference of Weights and Measures by agreeing on a standard metric system. The result was the International Metric System.
- 1968 The U.S. Congress directed the Secretary of Commerce to make a study to determine advantages and disadvantages of increased use of the Metric System in the United States. (P.L. 90-472)
- 1971 The Secretary of Commerce recommended that the United States change to the International Metric System deliberately and carefully through a coordinated national program.
- 1974 The United States decided, as a policy, to encourage educational agencies and institutions to prepare students to use the Metric System of measurement with ease and facility as a part of the regular education program. (Public Law 93-380)
- 1975 The Metric Conversion Act of 1975 was passed. It declared that the policy of the United States shall be to coordinate and plan the increasing use of metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the Metric System. (Public Law 94-168)
- 1976 The Education Commissioner suggested a metric implementation timeline for all schools in New York State. One of the suggestions was the use of metric in all grades and subjects by June 1980.
- 1977 An Act to amend the agriculture and market law was passed recently in New York State. One of the major features of the Act is that the Metric system has been adopted as the preferred system of measurement within this state, and voluntary conversion to the metric system is encouraged.

5.0 SUGGESTED COMPETENCIES FOR TEACHERS

5.1 SUGGESTED COMPETENCIES FOR ELEMENTARY TEACHERS IN METRIC SYSTEM

- The teacher will demonstrate, when speaking or writing, adequate command of metric language by using correct spellings, pronunciations and style. (Command will mean here, use of terms as approved by the National Bureau of Standards.)
- The teacher will demonstrate skill in estimation of measures to an acceptable accuracy. (To be defined during each workshop.)
- Given a metric unit, the teacher will show object(s) that approximate that unit.
- The teacher will select appropriate metric instruments for measurement and express the measure in desired/appropriate units.
- The teacher will show skill in the use of basic units of length, mass, time, and temperature; supplementary units of area, volume, speed (velocity), density (mass density), and other units like liter, metric ton (tonne).
- The teacher will use prefixes from kilo to milli, (mega - micro).
- The teacher will convert from one unit to another within the same base, including square and cubic measures.
- The teacher will state an appropriate relationship between customary and metric system. (At least, for the time being)

5.2 LANGUAGE OF THE METRIC SYSTEM

5.2.1 General

5.2.1.1 The 'er' Controversy

The International System of Units (Système International d'Unités, SI) was defined and given official status by the 11th General Conference on Weights and Measures (CGPM), 1960. The basic unit of length, as recommended by CGPM, is 'metre' and spelled as " m e t r e ". The National Bureau of Standards, (NBS), U.S. Department of Commerce, through the issue of guidelines (November 1974), recommended, but did not require, the use of the spelling "metre" for the unit, "meter", for the instrument. "The ultimate goal", as it said, was "to obtain uniformity throughout the world."

The spelling recommended for 'litre' by the CGPM is "l i t r e". NBS, did not show any preference between 'liter' and 'litre' in their 1974 guidelines.

However, NBS Guidelines were later (August 1975) revised in accordance with a directive regarding the spellings as "meter" and "liter".

Recently, a survey conducted by this project revealed that 82% of elementary teachers prefer 'er' style of spellings as opposed to 3% who favor 're' style; for about 15% it made no difference.

We will, therefore, use in all communications the spellings "meter" and "liter" in the manner recommended by the National Bureau of Standards.

5.2.1.2 The Mass and Weight Confusion

Considerable confusion exists in the use of the term weight as a quantity to mean either force or mass. In commercial and everyday use, the term weight nearly always means mass; thus, when one speaks of a person's weight, the quantity referred to is mass.

- Mass: Mass is a measure of the amount of material contained in a body, remains constant regardless of gravitational pull and must be measured with a balance scale. Mass is expressed in kilograms. Mass remains the same anywhere in the universe.
- Weight: Weight is a measure of the gravitational pull on that body and, therefore, it varies with the amount of gravitational pull. It is measured with a spring balance. It is possible for a body to become weightless but never massless.

5.2.2 Writing Styles

5.2.2.1 Capitals

- Units: When written in full, the names of all units start with a lower case letter, except at the beginning of a sentence. Note that in degree Celsius the unit "degree" is lower case but the modifier "Celsius" is capitalized. The "degree centigrade" is obsolete.

Example: - The distance from Albany to New York City is 240 kilometers.

- Meter is the base unit for length.

- Symbols: Unit symbols are written with lower case letters except that the first letter is upper case when the name of the unit is derived from the name of a person.

Examples:	<u>Name</u>	<u>Symbol</u>
	meter	m
	ampere	A
	kilogram	kg
	kelvin	K

- Prefixes: The symbols for numerical prefixes for exa (E), peta (P), tera (T), giga (G), and mega (M) are written with upper case letters, all others with lower case letters. All prefixes are written in lower case letters when written out in full, except where the entire unit name is written in upper case letters.

Examples:	megaton	Mt
	megawatt	MW
	kilogram	kg

5.2.2.2 Plurals

- When written in full, the names of units are made plural when appropriate. Fractions (both common and decimal) are always singular.

Examples: - The length of this room is 6 meters.
- 1/2 liter
- 0.75 meter

- Symbols for units are the same in singular and plural (no "s" is ever added to indicate a plural).

Example: - Dimensions of this room are 6 m, 5 m, and 3 m.

5.2.2.3 Periods

A period is NOT used after a symbol, except at the end of a sentence.

Example: - 2 m is the length of this stick.
- This stick is 2 m long
- Length of this stick is 2 m.

5.2.2.4 Decimal Points

The dot is used as the decimal point and is placed on the line. In numbers less than one, a zero must be written before the decimal point.

Examples: - \$2.50
- 1.60 meters in length
- 0.75 liter of milk

5.2.2.5 Grouping of Digits

- Separate digits into groups of three, counting from the decimal sign. The comma should not be used. Instead, a space is left to avoid confusion, since many countries use a comma for the decimal point.
- In numbers of four digits, the space is not recommended, unless four-digit numbers are grouped in a column with numbers of five digits or more.

Examples:	100	10 000
	1000	1 000
	2 345 670	256 789

5.2.2.6 Spacing

- In symbols or names for units having prefixes, no space is left between letters making up the symbol or the name.

Example:	<u>Prefix</u>	<u>Unit</u>	
	k	m	km kilometer

When a symbol follows after a number to which it refers, a space must be left between the number and the symbol (except for degree, minute, and second of angle).

Examples:	2 m	5 kilograms
	17 °C	17 degrees Celsius
	25° 35' 56"	

5.2.2.7 Compound Units

- In the symbol for a compound unit that is formed by the multiplication of two or more units, a centered dot is used.

Example: N·m

- In the name for such a unit, a hyphen is recommended (or a space is permissible) but never a centered dot.

Example: newton-meter or newton meter.

5.3 Key Terms

- Metrology: The science of weights and measures or of measurement.
- Customary System: The predominant measurement system in the United States commonly known as the English (or American) system of weights and measures. It includes such commonly used units as inch, foot, yard, mile, pint, quart, gallon, pound, Fahrenheit.
- Metric System: Developed in France at the time of the French Revolution, this measurement system was based on three fundamental units: the meter, the gram, and the second. Since then the system has been refined.
- International Metric System: The up-to-date version of the metric system is called Le Systeme International d'Unites, in short SI. This incorporated seven base units, two supplementary units and a series of derived units, and a set of prefixes.
- Transition Period: The length of time needed for a nation to become predominantly, though not exclusively, metric.
- Mettrication: National changeover that would result in acceptance of metric as the preferred system of measurement and, ultimately, thinking primarily in metric terms instead of primarily in customary terms.
- Unit: Any arbitrarily chosen quantity used as a standard for assessing the relative sizes of other quantities of a similar nature.
- Base Unit: Any of seven precisely-defined units in the modernized metric system (SI), which are regarded as the basis for all other units in SI. These base units include the meter, kilogram, second, ampere, kelvin, mole and candela.
- Derived Unit: An SI-based measuring unit obtained by combining base units through multiplication or division. Several derived units have been given special names and symbols; examples are the joule (J), the watt (W), and the volt (V).
- Prefix: One of a series of names and symbols that form decimal multiples and submultiples of SI units. SI prefixes range from exa-, which represents 10^{18} times a unit, to atto-, which represents 10^{-18} times a unit. A prefix is always joined to a unit, and cannot stand as a word by itself.

5.4 SI Metric System

- Metric System is formally known as the International System of Units. (SI)
- The SI System is constructed from seven base units and two supplementary units.
- The seven base units are the following:

Quantity	Name	Symbol
length	meter	m
mass ¹⁰	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature ¹¹	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

During this workshop, most of the time we will talk about only four quantities with base units: length, mass, time and temperature.

- The two supplementary units are the following:

Quantity	Name	Symbol
plane angle	radian	rad
solid angle	steradian	sr

¹⁰ Weight is commonly used term for mass. Please refer to section 5.2.1.2 for details.

¹¹ Celsius temperature: As a special consideration, it is acceptable to use the Celsius temperature (symbol t) defined by $t = T - T_0$ where T is the thermodynamic temperature, expressed in kelvins, and $T_0 = 273.15K$ by definition. The unit "degree Celsius" is thus equal to the unit "kelvin" when used as an interval or difference of temperature. Celsius temperature is expressed in degrees Celsius (symbol °C). Recently (Federal Register: October 26, 1977) degree Celsius has been added as an SI derived unit in Table 2 of SI derived units with special names.

- There are some other units, we will be using during this workshop. These are SI derived units expressed in terms of base units.

Quantity	SI Unit	Unit Symbol
area	square meter	m^2
volume	cubic meter	m^3
speed, velocity	meter per second	m/s
density, mass density	kilogram per cubic meter	kg/m^3

- There are some other units which are not part of the SI but are used so widely that it is impractical to abandon them. We will use the following units:

Name	Symbol	Value in SI Unit
minute	min.	1 minute = 60 s
hour	h	1 hour = 60 minutes = 3600 s
day	d	1 d = 24 h = 86 400 s
degree (angle)	°	1° = $(\pi/180)$ rad
minute (angle)	'	1' = $(1/60)^\circ = (\pi/10\ 800)$ rad
second (angle)	"	1" = $(1/60)' = (\pi/648\ 000)$ rad
liter ¹²	ℓ	1 ℓ = 1 dm ³ = 10 ⁻³ m ³
metric ton (tonne)	t	1 t = 10 ³ kg
hectare (land area)	ha	1 ha = 10 ⁴ m ²

- For use with the SI units there is a set of 16 prefixes to form multiples and sub-multiples of these units. (For mass the prefixes are to be applied to the gram instead of to the SI Unit, the kilogram). We will use the following 8 prefixes:

Prefix	Symbol	Factor
mega-	M	1 000 000
kilo-	k	1 000
hecto-	h	100
deka-	da	10
deci-	d	1/10 or 0.1
centi-	c	1/100 or 0.01
milli-	m	1/1 000 or 0.001
micro-	μ	1/1 000 000 or 0.000 001

¹²

Capital "L" recommended in December 10, 1976 Federal Register.

5.5 Preference in the Choice of Units

WHERE YOU USED:	NOW YOU SHOULD USE:
- Length - Fraction of an inch - Inches - Feet - Yards - Miles - Mass (Weight)¹³ - Ounces - Pounds - Short tons (2,000 pounds) or Long tons (2,240 pounds) - Area - Acre¹⁴ - Square inch - Square feet - Square yard - Capacity - fluid ounces - quarts and gallons - bushels - Volume - cubic inches - cubic feet - cubic yards - Temperature - degrees Fahrenheit - Speed - miles per hour (m.p.h.) - Gas Consumption - miles per gallon	- millimeter - centimeters - centimeters/meters - meters - kilometers - grams - kilograms - metric tons (tonnes) - hectare - square centimeter - square centimeter - square meter - milliliters - liters - hectoliters (liters are preferred instead) - cubic centimeters - cubic centimeters - cubic meters - degrees Celcius - kilometers per hour (km/h) - kilometers per liter (km/l)

¹³ For explanation, see Section 5.2.1.2.

¹⁴ Other units are expressed in square units corresponding to units of length, but never in units of length.

6.0 SUGGESTED COMPETENCIES FOR STUDENTS

6.1 FRAMEWORK FOR ORGANIZING STUDENT COMPETENCIES IN METRIC MEASUREMENT

● Perceiving

- Perception of length
- Perception of mass
- Perception of temperature
- Perception of area
- Perception of volume
- Perception of time

● Comparing

- Comparison of length
- Comparison of mass
- Comparison of temperature
- Comparison of area
- Comparison of volume
- Comparison of time

● Measuring

- Introduction of Non-Standard Measures

- Length
- Mass
- Temperature
- Area
- Volume
- Time

- Introduction of Standard Measures: SI Units

- Length
- Mass
- Temperature
- Area
- Volume
- Time

● Approximating and Estimating

- Developing Estimation Skills

- Length
- Mass
- Area
- Volume

- Evaluation of Estimation Skills

● Reading Scales and Instruments

● Using Smaller Units for Better Approximation (Accuracy)

6.2 SUGGESTED COMPETENCIES FOR ELEMENTARY SCHOOL STUDENTS

6.2.1 General Statement: Objectives - Competencies

The goal of this program is to initiate development of learner's competence in the measurement of length, mass, area, volume, time and temperature in the appropriate metric measuring units (SI). Objectives similar to the following will direct the activities in the courses during training to achieve the desired level of competency. A sample of selected objectives have been developed. Metric units used are in accord with the latest publications on the subject by NBS.

6.2.2 A Sample of Selected Objectives for Primary Grades

6.2.2.1 Length

The student will be able to:

- identify a meter stick
- use a meter-centimeter ruler
- use a centimeter-millimeter ruler
- compare the lengths of two objects longer than, shorter than, equal to-
- use arbitrary (non-standard) units for measuring length
- measure height of his peers in centimeters
- state his own height in centimeters
- record his own height in centimeters
- measure distance in whole centimeters
- measure distance in whole decimeters
- measure distance in whole meters
- select an appropriate measure (of m, dm, and cm) to find the length of given objects
- order objects from tallest (longest), to shortest
- estimate measurements in centimeters
- estimate measurements in meters
- measure lengths in meters and centimeters
- estimate lengths in meters and centimeters
- use the term kilometer to refer to longer distances
- observe and state that $100\text{ cm} = 1\text{ m}$.
- observe and state that $10\text{ mm} = 1\text{ cm}$.
- observe and state that $1000\text{ m} = 1\text{ km}$.
- measure short lengths in terms of millimeters
- measure perimeters of given objects
- continue working with previously learned measures

6.2.2.2 Area

The students will be able to:

- compare surface areas (i.e. larger area-size, smaller area-size) of objects with the same shape.
- express the area of a region using a non-standard unit
- express the area of a region using a supplied unit area
- find the area of a region through surface covering
- estimate the area of a region by using a graph paper

6.2.2.3 Volume (Capacity)

The student will be able to:

- compare volumes (i.e., holds more or less than)
- measure the capacity of the given container using an arbitrary (non-standard) unit
- identify a liter measure
- use a liter measure to fill a container to a liter mark
- measure the volume of containers in whole liters
- measure volume of containers to the nearest liter
- measure small volumes in milliliters
- measure volume of liquids in milliliters or liters or both
- observe and state that 1,000 milliliters = 1 liter
- continue working with previously learned measures

6.2.2.4 Mass

The student will be able to:

- compare masses (i.e., lighter than, heavier than)
- select heavier or lighter object using the balance scale
- measure the mass of a given body using non-standard units
- measure his own weight in kilograms
- state his own weight (mass) in kilograms
- record his own weight in kilograms
- identify grams and kilograms as measures used for mass
- weigh and compare objects in grams
- weigh and compare objects in kilograms
- assess (estimate) the mass of a given body
- state that 1000 grams = 1 kilogram
- continue working with previously learned measures

6.2.2.5 Temperature

The student will be able to:

- identify thermometers
- read a Celsius thermometer and state the temperature
- observe that freezing temperature of water on a Celsius thermometer is recorded zero (0°C)
- observe that boiling temperature of water on a Celsius thermometer is recorded 100°C
- observe that average normal temperature of the human body is approximately 37 degrees Celsius 37°C
- read and record temperatures in degrees Celsius

6.2.2.6 Time

To enable children to:

- develop the concept of an interval of time
- appreciate intervals of time in everyday situations
- use a calendar in their daily activities
- tell time - including twenty-four hour clock
- calculate time intervals
- have the idea of speed, faster/slower

6.2.2.7 General

The student will be able to recognize and write symbols for the following:

- meter
- centimeter
- millimeter
- square centimeter
- square meter
- liter
- milliliter
- gram
- kilogram
- degree Celsius

6.2.3 A Sample of Selected Objectives for Intermediate Grades

6.2.3.1 Length

The student will be able to:

- recognize and use standard units of length
- select appropriate units for recording measurements of lengths
- measure lengths in meters, centimeters, and millimeters
- state the relationship among meter, centimeter and millimeter
- recognize and write symbols for the following: meter, centimeter, millimeter
- recognize the measuring of the following prefixes: milli, centi, deci, deka, hecto, kilo
- use the prefixes described above
- record lengths expressed in meters and centimeters in decimal notations. For example: Height of Tom is 1.42 meters
- measure a given line segment in centimeters and millimeters and record in decimal notations
- measure perimeters of given triangles, rectangles, and squares in centimeters and millimeters
- recognize 'kilometer' as a unit for measuring longer distances
- state the relationship among kilometer, hectometer, dekameter and meter
- estimate lengths in meters and centimeters
- record lengths (expressed in meters, centimeters and millimeters) in the decimal system. For example, 5.375
- draw a line segment of a given length specified in centimeters and millimeters by using a ruler
- find the relation between the circumference and diameter of a circle
- convert m-cm, m-mm, cm-m, mm-m, and mm-cm in simple conversions

6.2.3.2 Area

The student will be able to:

- measure the surface area of a given object using a cm^2 unit
- measure the surface area of a given object using a dm^2 unit
- measure the area of the given surface using an m^2 unit
- state the area of a given region in cm^2 or dm^2 or m^2
- record the area of a given region in cm^2 , or dm^2 or m^2
- demonstrate with the help of a graph paper that $1 \text{ cm}^2 = 100 \text{ cm}^2$
- demonstrate that $1 \text{ m}^2 = 10\,000 \text{ cm}^2$
- select a proper unit for area measure to express the area of a given region
- estimate areas of regular shaped objects
- demonstrate that the area of any triangle is one-half the area of a rectangle with the same base and the same height (altitude)
- distinguish between the meanings of area and perimeter
- calculate the area of rectangular objects
- calculate the area of a triangular region
- recognize and use the following units: square centimeter, square decimeter and square meter

6.2.3.3 Volume

The student will be able to:

- measure the volume of a given object by using a centimeter cube as the selected unit
- calculate the volume of a cuboid using linear measurements
- calculate the volume of a cuboid using the number of unit cubes in a layer as the number of layers, and the volume of a slice and the number of slices
- estimate volumes of regular shaped (cuboids) boxes, cartons
- choose appropriate units (cm^3 , dm^3 , m^3) to describe the volume of a given body
- state the relationship between a cm^3 and a m^3
- convert $\text{cm}^3 - \text{m}^3$ and $\text{m}^3 - \text{cm}^3$

6.2.3.4 Capacity

The student will be able to:

- recognize and use standard units of capacity (liters and milliliters).
- select appropriate units for recording measurements of capacity
- measure capacity of containers in liters and nearest milliliters
- state the relationship between a liter and milliliter
- recognize and write symbols for the following: liter and milliliter
- find the capacity of non-calibrated containers in liters and milliliters
- estimate certain capacities in milliliters and liters
- convert l-ml and ml-l
- indicate that one cubic decimeter (dm^3) or one thousand (1 000) cubic centimeter (cm^3) are equivalent to one liter

6.2.3.5 Mass

The student will be able to:

- recognize and use standard units of mass
- select appropriate units for recording measurements of mass
- measure the mass of the objects to the nearest whole gram
- measure the mass of objects to the nearest kilogram
- measure the mass of the objects in kilogram and nearest gram
- state the relationship between a kilogram and a gram
- recognize and write symbols for the following: gram, kilogram
- recognize the measuring of the following prefixes: milli, centi, deci, deka, hecto, kilo
- use the prefixes described above
- estimate and measure the mass of a given object in kilograms and grams
- convert kg-g, and g-kg

6.2.3.6 Temperature

The student will be able to:

- indicate the freezing point of water (0°C) on the Celsius thermometer
- indicate the boiling point of water (100°C) on the Celsius thermometer
- use a Celsius thermometer to measure (read) the temperature of a given substance to the nearest degree Celsius
- record his reading of temperature of a given substance (or situation like room temperature) in degrees Celsius

6.2.3.7 General

The student will be able to

- show an awareness of the simplicity and importance of becoming familiar with metric system
- select the best unit of measurement for a given object in a given context
- define kilo as meaning 1,000
- state that milli means
- recognize and write symbols for the following: (kilo, hecto, deka, deci, centi, milli) meter, gram, liter; square centimeter, square meter; cubic centimeter, cubic meter; degree Celsius, hour, minute and seconds.

6.3 ORGANIZATION OF STUDENT COMPETENCIES THROUGH HEAD AND HEART

6.3.1 Cognitive: Head

Level I	Knowledge	Student identifies common units of measurement in the metric system.
Level II	Comprehension	Student explains the metric system.
Level III	Application	Student solves mathematical problems using metric units.
Level IV	Analysis	Student recognizes the simplicity of learning and using the metric system.

6.3.2 Affective: Heart

Level I	Receiving	Student shows an awareness of the importance of becoming familiar with metric units.
Level II	Responding	Student voluntarily participates in class activities involving measurement in the metric system.
Level III	Valuing	Student recognizes the role metrication will play in improving the U.S. position in world trade.
Level IV	Organization	Student relates the need for the American society, to move to the metric system, in a planned way.
Level V	Characterization	Student develops a willingness to learn and use the metric system.

6.4 SUGGESTED GUIDELINES FOR TEACHING MEASUREMENT WITH THE METRIC SYSTEM¹⁵

- The focus of instruction should be on measurement, with the metric system evolving and taking its role as the standard system of measurement.
- Before children can understand the metric system or any other system of measurement, they must have experiences in measuring. They must understand what measurement is. Some prerequisite skills and understandings are essential before any standard measures are used.
- After prerequisite knowledge and skills are attained, nonstandard measures should be used to develop the concept of why a standard system of measurement is needed, as well as to extend the concepts of what measuring means and of how things can be measured in various ways. (Only when the child understands how arbitrary the choice of a unit actually is will he realize the importance of standardization in measurement and appreciate that the history of measurement is essentially a struggle for standardization.)
- The logic of using a measurement system based on ten—to correspond with our numeration system—is then developed, and the metric system is introduced.
- Begin with linear measures, because the metric units of length are the basic units from which the units of mass and volume are derived. For children in the intermediate grades, begin with the meter as the basic unit; for smaller children who may have difficulty handling the meter stick (and who do not yet know the numbers to 100 sufficiently), begin with the centimeter as the basic unit.
- In the elementary school, teach the metric system as the system of measurement; later, the customary system may be discussed as one of the other systems of measurement. Schools may have to teach some of the customary measures along with teaching the metric system for a while, since the country as a whole will offer examples of both for years to come. (The customary system happens to be the one the children's parents used.)
- Avoid conversion exercises, concentrating on use of the metric system. The individual needs to learn metric measurement by itself and thus learn to think in that language of measurement. Children who have not learned any system of measurement will have little difficulty learning and accepting the metric system.
- Limit conversions within the metric system to commonly used units adjacent in size. Present-day metric materials often ask students to perform extensive conversions, such as changing kilometers to decimeters. Just as useless are exercises requiring addition of unlike units; rarely will this be needed in actual metric situations. Instead of stating 4 decimeters 3 centimeters, the measure will be given as 43 centimeters; instead of 5 meters 16 centimeters, we will say 5.16 centimeters or 5.16 meters. Children will need to understand the relationship between measures, but they should be encouraged to use the standard form.
- Use actual units and measuring instruments; avoid completely the use of scaled-down versions sometimes found in current text materials.
- Develop the understanding that the appropriate instrument should be used for different measurement purposes: the meter stick for length, the balance

for weight (mass), the container for volume, the clock for time, the thermometer for temperature.

- The units should be introduced at the point at which they are to be used. Concentrate on those units necessary from a utilitarian standpoint at all age levels, including adult. Do not teach the metric unit tables per se.
- Estimations should be emphasized, such as, "About how many matchbook covers long is the desk?" or "About how many grams of sugar do you put in a cup of coffee?" Verify estimates with nonstandard measures and later with metric measures. Develop the meaning of and a feeling for the size of units through experiences centering on estimating and checking those estimates.
- Stress the idea that measurement is approximate. Schools have given children many illustrations of "exact" measures; measurement is not as precise as we have made it seem. Precision is partially dependent on the unit of measurement we use.
- With pupils who already know the customary system, as well as with adults, approximate conversions may be needed. Relate metric measures to common objects and to body measures.

The meter is a little longer than a yard.

The liter is a little larger than a quart.

The gram is about the weight of an ordinary paper clip.

The kilogram is a little heavier than 2 pounds.

Body temperature is about 37° C.

- Use metric units at every opportunity, including other subject matter fields.
- The prefixes should be introduced as they are needed. Association and presentation of the complete set of prefixes should be done late in the development and then it should be presented only to serve the function of noting the orderliness of the metric system and its relationship to our numeration system. The prefixes kilo, deci, centi, and milli are the only ones that will need to be stressed in the elementary school.
- Teach only the commonly used multiples and subdivisions and their corresponding prefixes and symbols; for instance.

cm, m	100 cm = 1 m
mm, cm	10 mm = 1 cm
m, km	1000 m = 1 km
g, kg	1000 g = 1 kg
ml, l	100 ml = 1 l

- Stress the importance of correct symbol usage, which is the same in all languages.
- Special emphasis should be given to symbols for area and volume units that contain superscripts. Additional emphasis on exponential and scientific notation will be needed in the elementary school.

- Discourage the use of common fractions with metric units except when needed to develop specific quantitative concepts; when a fractional term is used write it in decimal form, that is, "one-half" is written as ".5" or "0.5."

¹⁵ Taken from: Marilyn N. Suydam: "Metric Curriculum: Scope, Sequence, and Guidelines" in A Metric Handbook for Teachers. NCTM. 1973, pp. 83-85.

2

7.0 WORKSHOP PROGRAM

7.1 SUGGESTED SCHEDULE FOR METRIC EDUCATION WORKSHOPS

7.1.1 FIRST DAY

- SESSION IA (Approximate Time: 1 hour)
 - Brief introduction of the Metric Education Project: its purpose, operation, program and expected impact (Please refer to Section 1).
 - Role of School District Level Leaders
 - Workshop Evaluation: Questionnaire (Pre-Test)
 - A Historical note: Progress in the implementation of the (SI) Metric system at the national, state, regional, and local level.
 - Introduction to the (SI) Metric System: General Discussion
- Coffee Break (Approximate Time: 20 minutes)
- SESSION IB (Approximate Time: 1 hour 40 minutes)
 - Experiences with metric measurement: linear measure (Please refer to Section 8.4 for details)

7.1.2 SECOND DAY

- SESSION IIA (Approximate Time: 1 hour 20 minutes)
 - Experiences with metric measurement: surface measure - area (Please refer to Section 8.5 for details)
- Coffee Break (Approximate Time: 20 minutes)
- SESSION IIB (Approximate Time: 1 hour 20 minutes)
 - Experiences with metric measurement: Introduction to volume. (Please refer to Section 8.6 for details)

7.1.3 THIRD DAY

- SESSION IIIA (Approximate Time: 1 hour 20 minutes)

Experiences with metric measure: Introduction to Capacity
(Please refer to Section 8.7 for details)

- Coffee Break (Approximate Time: 20 minutes)

- SESSION IIIB (Approximate Time: 1 hour 20 minutes)

Experiences with metric measure: Introduction to mass
(Please refer to Section 8.8 for details)

7.1.4 FOURTH DAY

- Session IVA (Approximate Time: 1 hour)

Experiences with metric measure: Introduction to temperature
(Please refer to Section 8.9 for details)

- Short Break (Approximate Time: 5 minutes)

- SESSION IVB (Approximate Time: 1 hour)

Problems and concerns regarding implementation of metric
program in the school districts -- Discussion session

- Coffee Break: Get-together (Approximate Time: 25 minutes)

- SESSION IVC

Evaluation of the workshop: Questionnaire (Post-test)

NOTE: If team leaders need support material like video tapes, thermometers, etc., please contact the Project Director, Metric Education Project, Regional Planning Center, Albany.

8.0 SUPPORT MATERIAL

8.1 PROJECT PRODUCED MATERIAL

- The project has developed 5 modules, in addition to "An Elementary Handbook on Metric Education," and "pre-test" and "post-test" instruments for use during teacher training, on the following topics:
 - length
 - area
 - volume and capacity
 - mass
 - temperature
- Appropriate activities have been incorporated in these modules to cater to the needs of diverse learning styles of the target population.
- The material developed lays heavy emphasis on activities that involve a performance oriented approach.
- The material developed strictly adheres to the International System of Units (SI).
- The teaching strategies allow teachers to choose, design, and develop their own material for the classroom use. This material may result from adaptation of project developed metric educational activities.
- Teachers should be encouraged, during the training, to develop instructional material for the use in the classroom.
- The material developed includes interdisciplinary experiences.

8.2 MATERIAL FROM NEW YORK STATE DEPARTMENT OF EDUCATION

8.2.1 The State Education Department has published the following material:

- "Let's Use the Metric System: A Supplement to Mathematics K-6"
- "The Metric System: Ideal for Introducing the Metric System"

This material is available with the Bureau of Mathematics Education, State Education Department. Please direct your request to:

Mr. LeRoy Negus, Chairman
SED Metric Committee
Bureau of Mathematics Education
State Education Department
Albany, New York 12230

8.2.2 The following videotape programs along with teacher's guides are available with the Bureau of Mass Communication, State Education Department.

- Measure Metric
- The Metric System
- Metrics for Adults

Please direct your inquiries to:

Mr. Bernarr Cooper
Chief, Bureau of Mass Communications
State Education Department
Albany, New York 12230

8.3 SOME OTHER SOURCES

8.3.1 Books, Guides etc. for Activities

- From the National Council of Teachers of Mathematics, 1906 Association Drive Reston, Virginia 22091. (703) 620-9840:
 - Going Metric: Guidelines for Mathematics Teacher, grades K-8 by Walter W. Leffin. 47 pages, cost -- \$1.20.
 - A Metric Handbook for Teachers edited by Jon Higgins. Developed in cooperation with ERIC. 137 pages, cost - \$2.15.
 - Measurement in School Mathematics: 1976 yearbook
- From other Sources:
 - Addison-Wesley Company. The Metric System. Menlo Park, California, 1974, 95 pages. Also distributed free by local 7-Up soft drink plants and dealers.
 - Bitter, Gary G. et. al. Activities Handbook for Teaching the Metric System. 470 Atlantic Avenue, Boston, Massachusetts 02210, Allyn and Bacon, Inc. 1976, 378 pages.
 - Clark, Roy E. (compiled by). How to Teach Metric: Some Ideas, Metric Information Office, U.S. National Bureau of Standards, Washington, D.C. 20234. 63 pages.
 - Henderson, George L. and Glunn. Let's Play Games in Metrics - 177 Objective-Associated Games and Activities. 8259 Niles Center Rd., Skokie, Ill. 60076, National Textbook Company, 1974, 223 pages.
 - S.R.A., Inc. An Everyday Guide to the Metric System. Order from: Associated Press Books, 50 Rockefeller Plaza, New York, NY 10020. 1976, 63 pages.
 - Sohns, Marion; Buffington, Audrey. The Measurement Book - ENRICH Inc, Sunnyvale, CA 94086, 1977

8.3.2 Teaching aids and metric material is available from many companies. Some of them are listed below:

- | | |
|--|--|
| - Ohaus Scale Corporation
29 Hanover Road
Florham Park, New Jersey 07932 | - ENRICH Inc.
760 Kifer Road
Sunnyvale, CA 94086 |
| - New England School Supply
A Milton Bradley Company
P.O. Box 1561
Springfield, MA 01101
or
P.O. Box 86
Delmar, NY 12054 | - Creative Publications
P.O. Box 10328
Palo Alto, CA 94303 |

8.4 INTRODUCTION TO LENGTH

- Rationale: This session is designed to provide the participants with experiences that are related to linear measurement using metric units.
- Objectives:
 - Cognitive: Each participant will be able to state and record various measures in length using appropriate language and symbolization.
 - Performance: Each participant will be able to measure lengths (distances) of various objects using appropriate units, namely kilometer, hectometer, dekameter, meter, decimeter, centimeter, and millimeter.
- Materials: Measuring tapes
Meter Sticks
Half-meter sticks
10, 20, 30 centimeter rulers
objects (your choice) to measure length
- Vocabulary: basic unit
Meter length and meterstick
vocabularly of prefixes: kilo to milli
symbols for various units
- Evaluation: Pre-test Quiz
Post-test Quiz
Observation: participant measures and estimates lengths of objects. Participant develops appropriate instructional material for classroom use.

STRATEGY FOR SESSION IB: LENGTH

TOPICS	TIME APPROX.	STRATEGY FOR INSTRUCTION	EVALUATION ASSIGNMENT
Pre-test	10-15 minutes	Distribute test; explain purpose and directions; explain use of results, administer test.	Correct, return, use results as beginning point.
Basic Unit: Estimation of length	30-40 minutes	Distribute station worksheet. Participants will visit various stations and measure and record length of various objects. (See next page for worksheet)	Participants measure and record length on worksheet as directed.
Review concepts and skills taught.	30-40 minutes	Demonstration, discussion, etc. (For discussions, please refer to the list of objectives and suggested activities contained in the "module on length".)	Observation and informal evaluation of participants' answers. For additional classwork or outside assignment, have participants utilize objectives (Primary and/or Intermediate, Section 6.2.2 & 8.6.2.3), to develop materials similar to those contained in module on length.
Post-test	10-15 minutes	Post test will evaluate the objectives listed. (Leaders will develop post-test, similar to the pre-test.)	Read preliminary materials for next session. Review concepts, skills and procedures developed during the workshop.

STATION WORKSHEET - LENGTH

Station A: Practice in Estimation and Measurement: centimeters

Have objects measuring about 5-20 centimeters in length - like pencils, papers, books, etc. placed on a table. Encourage participants to guess the length of the objects and then, let them measure. Let them see the difference between their estimation and the actual length of the objects. Participants may like to record their results in the following Table.

Object	Estimated Length	Actual Length	Difference
	--- cm	--- cm	--- cm
	--- cm	--- cm	--- cm
	--- cm	--- cm	--- cm

Station B: Measuring Length in millimeters:

Place small-sized objects (less than 5 mm in length) like coins, paper clips, etc. Let participants find lengths of the objects in centimeters. Also, they can measure lengths in millimeters. If length of any object is a nearest whole number in centimeters and also a nearest whole number in millimeters, encourage them to establish relationship between a centimeter and millimeter. They can also measure the width of their thumb, palm, length of arm, etc.

Station C: Measuring heights:

Have a Height Measure stand (or use a measure tape) in one corner of the room. Let participants measure their own height in centimeters. They may like to record height measures in meters and centimeters.

Station D: Outdoor Activity: (meters and kilometers)

It will be a good activity to allow the participants to measure the perimeter of a parking lot. Through walking, each participant can develop an estimation of the length of his steps, can have a practice in estimating distances in meters and fraction of kilometer.

SAMPLE PRE-TEST/POST-TEST FOR LENGTH

1. The basic unit for linear measure in the metric system is _____
2. Centimeter is a larger/smaller unit of lineau measure in comparison to meter. _____
3. What, do you think, is the appropriate unit for measuring distance from Albany to New York City: (Put an X mark)
 - a. millimeter _____
 - b. meter _____
 - c. kilometer _____
 - d. hectometer _____ ✓
4. The most appropriate unit for recording your height would be:
 - a. millimeter _____
 - b. kilometer _____
 - c. centimeter _____
5. One kilometer length is the same as _____ meters.
6. Measure in millimeters the following line segment.

7. Fill in the blanks:
 - a. 1 meter = _____ centimeter
 - b. 1 kilometer = _____ dekameters
 - c. 1 centimeter = _____ millimeters
8. Match each word with the appropriate symbol by drawing lines and connecting them:

decimeter	m
millimeter	cm
dekameter	dm
centimeter	dam
meter	mm

8.5 INTRODUCTION TO AREA

- Rationale: This session is designed to provide the participants with experiences that are related to measurement of area using metric units.
- Objectives:
 - Cognitive: Each participant will be able to state and record various measures in area using appropriate language and symbolization.
 - Performance: Each participant will be able to measure area of various objects using appropriate units, namely square meter, square decimeter, square centimeter.
- Materials: Measuring tapes, and rulers of various sizes
Graph paper (cm^2)
Cardboard squares, rectangles, etc.
- Vocabulary: area, measure
square meter, square decimeter, square centimeter
- Evaluation: Pre-test quiz
Post-test quiz
Observation: participant measures, calculates, and estimates areas of objects
participant develops appropriate instructional material for classroom use.

STRATEGY FOR SESSION IIA: AREA

TOPICS	TIME APPROX.	STRATEGY FOR INSTRUCTION	EVALUATION ASSIGNMENT
Pretest	10-15 min.	Distribute test; explain purpose and directions; explain use of results, administer test.	Correct, return, use results as beginning point.
Measurement and Estimation of Area	35-40 min.	Derive area units from linear units. Distribute station worksheet. Participants will visit stations and measure, calculate, & record the area of various objects (See next page for worksheet)	Participants measure and record area on worksheet as directed.
Review concepts and skills taught	15 minutes	Demonstration, discussion, etc. (For discussions, please refer to the list of objectives and suggested activities contained in the module on "area".	Observation and informal evaluation of participants' answers. For additional classwork or outside assignment, have participants utilize objectives. (Primary and/or Intermediate; Section 6.2.2 and 6.2.3) to develop materials similar to those contained in module on "area".
Post-test	15 minutes	Posttest will evaluate the objectives listed. (Leaders will develop posttest, similar to the pretest).	Read preliminary materials for next session. Review concepts, skills & procedures developed during the workshop.

STATION WORKSHEET - AREA

Station A: Practice in estimation and measurement: square centimeters

Arrange different sized sheets of paper/cardboard in regular shapes (rectangles, squares, triangles, etc.). Encourage the participants to estimate the areas of these sheets and, then, let them measure. Participants may like to record their results in the following table:

Object	Estimated Area	Measure of Length	Measure of Width	Calculated Area	Difference
	cm ²	cm	cm	cm ²	cm ²
	cm ²	cm	cm	cm ²	cm ²
	cm ²	cm	cm	cm ²	cm ²

Station B: Practice in estimation and measurement: square centimeters: graph

Let participants use small irregular shaped objects to find area with the help of centimeter graph. First, they may like to guess and then can use graph paper to find out the area. Let them check their results.

Station C: Practice in estimation and measurement: square meters

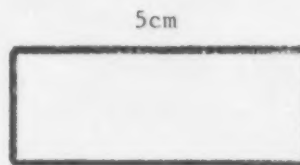
Let the participants estimate the floor area, area of the chalkboard, area of the walls of the workshop room.

SAMPLE PRE-TEST/POST-TEST: AREA

1. The area of the adjoining figure is

_____ cm^2

3cm



2. The area of the above figure is expressed in dm^2 would be _____

3. If there are four figures with the following dimensions:

Figure A: a rectangle which is 3 m long and 2 m wide

Figure B: a square which measures 2, 5 dm on a side

Figure C: another rectangle which is 2 m 8 dm long and 2 m 2 dm wide

which of these have the largest area?

4. Fill in the blank:

a. $1 \text{ dm}^2 = \text{_____ cm}^2$

b. $1 \text{ dm}^2 = \text{_____ m}^2$

c. $1 \text{ m}^2 = \text{_____ cm}^2$

5. The area of a standard classroom would normally be expressed in:

a. square centimeters

b. square dekameters

c. square decimeters

d. square meters

8.6 Introduction to Volume

- Rationale

This session is designed to provide the participants with experiences that are related to volume (cubic units) and the metric system.

- Objectives

- Cognitive: The participant will be able to state and record various volumes using the appropriate language and symbolism.
- Performance: The participant will be able to measure the volume of various objects to the nearest cubic unit. The student will be able to estimate the volume of various containers or objects.

- Materials

20-30 centimeter rulers (millimeter marks)
20-30 meter-tapes (optional)
Boxes (shoe boxes, chalk boxes, etc.)
Non-standard objects or containers (rocks, sand, soda bottles, etc.)

- Vocabulary

cubic unit
cubic centimeter
cubic meter
cubic deci
volume

- Evaluation

Pre-test quiz
Post-test quiz
Observation of participants measuring and estimating volumes

STRATEGY FOR SESSION IIB: VOLUME

• Pretest	10-15 min.	• Distribute test; explain purpose and directions; explain use of results, administer test.	Correct, return, use results as beginning point.
• Measurement of Volume	15-20 min.	• Derive unit of volume from linear unit. Participants will visit various stations and measure, calculate and record the volume of various objects. (See next page for worksheet.)	Participants measure and record volume on worksheet as directed.
• Estimation of volume	10-15 min.	• Display pictures showing various sizes of food packs, (wooden boxes, etc.) Participants will estimate the approximate volume of these.	Each poster/picture will have an answer window for participant to check the accuracy of his/her answer.
• Review concepts and skills taught.	15 minutes	• Demonstration, discussion, etc (For discussions, please refer to the list of objectives and suggested activities contained in the module on "Volume and Capacity".	Observation and informal evaluation of participants' answers. For additional classwork or outside assignment, have participants utilize objectives (Primary and/or Intermediate; Section 6.2.2 and 6.2.3) to develop materials similar to those contained in in module on "Volume and Capacity."
• Posttest	15 minutes	• Posttest will evaluate the objectives listed. (Leaders will develop posttest, similar to the pretest).	Read preliminary materials for next session. Review concepts, skills, and procedures developed during the workshop.

VOLUME STATIONS

- STATION A: Have small boxes that are rectangular (or cubic) in shape-- shoe box, cereal box, box for chalk, etc. Participants will measure and record the lengths of the edges of the boxes and then compute the volume in cubic centimeters. (Provide, if necessary, plastic models of cubic centimeters in order to assist participants).
- STATION B: (Not really a station) Have participants measure the dimensions of larger object -- large boxes, tables, desks, the room, cabinets, etc. -- in decimeters or meters and then compute the volume in cubic decimeters and cubic meters.
- STATION C: Have several irregular shaped objects displayed on a table or counter. Participants will estimate the volume of the objects in appropriate units. After estimating participants will make appropriate measurements and then refine original estimations.

SAMPLE PRE-TEST/POST-TEST FOR VOLUME

1. Name two of the standard metric units in measuring volume.
2. The volume of shoe box would normally be expressed in:
 - a. Cubic centimeters
 - b. Cubic meters
 - c. Cubic kilometers
3. The volume of a standard classroom would normally be expressed in:
 - a. Cubic centimeters
 - b. Cubic meters
 - c. Cubic kilometers
4. Find the volume of a cube in which each edge is 10 cm.
5. Find the volume of a rectangular storage bin that measures 15 m by 12 m by 10 m.
6. Convert 15 cubic decimeters to cubic centimeters.

8.7 INTRODUCTION TO CAPACITY

- Rationale: This session is designed to provide the participant with experiences that are related to capacity and the metric system.
- Objectives: - Cognitive: The participant will be able to state and record various capacity measures using the appropriate language and symbolization.

- Performance: The participant will be able to measure the capacity of various containers to the nearest liter or milliliter. The participant will be able to estimate the capacity (in liters or milliliters) of various containers.
- Materials: Graduated cylinders or beakers (marked in liters and milliliters)
Odd shaped containers (bottles, cans, pans, etc.) ranging in capacity from 50-100 milliliters to 15-20 liters.
- Vocabulary: capacity
liter
milliliter
kiloliter
- Evaluation: Pretest quiz
Posttest quiz
Observation of participants measuring and estimating capacities.

STRATEGY FOR SESSION IIIA: CAPACITY

TOPICS	TIME APPROX.	STRATEGY FOR INSTRUCTION	EVALUATION ASSIGNMENT
Pretest	10-15 min.	Distribute test; explain purpose and directions; explain use of results, administer test.	Correct, return, use results as beginning point.
Basic Unit	15-20 min.	Distribute station worksheet. Participants will visit various stations & measure and record the capacity of various objects. (See next page for worksheet.)	Participants measure and record capacity on worksheet as directed.
Estimation of capacity	15-20 min.	Display pictures showing various food packs (liquid containers). Participants will estimate the approximate capacity of these.	Each poster/picture will have an answer window for participant to check the accuracy of his/her answer.
Review concepts & skills taught	15 minutes	Demonstration, discussion, etc. (For discussions, please refer to the list of objectives & suggested activities contained in the module on "Volume and Capacity"	Observation and informal evaluation of participants' answers. For additional classwork or outside assignment, have participants utilize objectives (Primary and/or Intermediate Section 6.2.2 and 6.2.3), to develop materials similar to those contained in module on "Volume and Capacity".
Posttest	15 minutes	Posttest will evaluate the objectives listed. (Leaders will develop posttest, similar to the pretest).	Read preliminary materials for next session. Review concepts, skills, and procedures developed during the workshop.

STATION WORKSHEET - CAPACITY

Station A: Containers capable of holding two to twenty liters of liquid, sand, etc. Using a liter container, participants fill containers and record results.

Station B: Containers capable of holding approximately one or two liters. Using a liter container (and then milliliter container), participants fill containers and record results. Containers could be odd shaped bottles, cans, milk cartons, etc.

Station C: Containers capable of holding less than one half of a liter. Using a milliliter containers, participants fill containers and record results. Containers could be odd shaped medicine bottles, vitamin pill bottles, etc.

Station D; Display or identify containers of various capacities and have participants estimate the capacities in liters and/or milliliters. (Allow participants to physically verify one of their estimates)

SAMPLES PRETEST/POSTEST FOR CAPACITY

1. What is the most widely used unit for measuring capacity in the metric system? _____
2. Liter is a larger/smaller unit of measure than the kiloliter.

3. The most appropriate unit of measure for measuring the amount of water in a swimming pool is (liter, centiliter, kiloliter, milliliter). _____
4. The most appropriate unit of measure for measuring an amount of milk in a carton is (liter, kiloliter, milliliter). _____
5. The most appropriate unit of measure for measuring the amount of gasoline in an automobile is _____.
6. The most appropriate unit of measure for measuring the amount of liquid in an eyedrop prescription is _____.
7. Fill in the blank:
 - a. 1 liter = _____ milliliters
 - b. 1 kiloliter = _____ liters
 - c. 100,000 milliliters = _____ liters

8.8 INTRODUCTION TO MASS

- Rationale: This session is designed to provide the participants with experiences that are related to the measurement of mass using metric units.
- Objectives:
 1. Cognitive: Each participant will be able to state and record various measures of mass using appropriate language and symbolization.
 2. Performance: Each participant will be able to measure mass of various bodies (objects) using appropriate units, namely kilogram, hectogram, dekagram, gram, decigram, centigram, and milligram.
- Materials: A pair of scales

Weights of various mass - 1g, 2g, 5g, 10g, 20g, 50g, 100g, 200g, 250g, 500g, and 1000g.

Objects (your choice) to find mass
- Vocabulary: basic unit

distinction between mass and weight

vocabulary of prefixes: kilo to milli

symbols for various units
- Evaluation: pre-test quiz

post-test quiz

observations: participants weighs and estimates mass of various objects

Participant develops appropriate instructional material for classroom use.

STRATEGY FOR SESSION IIIB: MASS

TOPICS	TIME APPROX.	STRATEGY FOR INSTRUCTION	EVALUATION ASSIGNMENT
• Pretest	10-15 minutes	• Distribute test; explain purpose and directions; explain use of results, administer test.	Correct, return, use results as beginning point.
• Basic Unit	15-20 minutes	• Distribute station worksheet. Participants will visit various stations and measure, calculate and record the mass of various objects (See page for suggested worksheet.)	Participants measure and record mass on worksheet as directed.
• Estimation of mass	15-20 minutes	• Participants will estimate the approximate mass of given bodies.	Participant to check the accuracy of his/her answer.
• Review concepts and skills taught	15 minutes	• Demonstration, discussion, etc. (For discussions, please refer to the list of objectives and suggested activities contained in the module on "Mass")	Observation and informal evaluation of participants' answers. For additional classwork or outside assignment, have participants utilize objectives (Primary and/or Intermediate; Sections 6.2.2 and 6.2.3) to develop materials similar to those contained in module on "Mass".
• Posttest	15 minutes	• Posttest will evaluate the objectives listed. (Leaders will develop posttest, similar to the pretest.)	Read preliminary materials for next session. Review concepts, skills, and procedures developed during the workshop.

STATION WORKSHEET - MASS

Station A: Practice in Estimation & Measurement: Grams

Let participants make their own scale using a meter (or half-meter) stick, thread, etc. if possible. Otherwise, provide a balance. Allow participants to estimate names of objects like a penny, nickel, dime, paperclip, etc. in grams and then let them check by weighing in the balance. Participants may like to record their results in the following table:

Object	Estimated Mass	Actual Mass	Difference
Penny	--- g	--- g	--- g
Nickel	--- g	--- g	--- g
Dime	--- g	--- g	--- g
Paperclip	--- g	--- g	--- g

Station B: Practice in Estimation and Measurement: Kilograms

Participants can have similar experience in estimation and measurement of mass by using heavier objects like books, cartons filled with sand, peanutbutter jar, etc.

Station C: Who is Heavier? Use of Bathroom Scale

Participants can have fun by estimating their respective weights and then comparing the actual weights measured in kilograms by using a bathroom scale. (A two-hundred-twenty pounder may feel good when he finds he weighs only 100 kilograms!)

SAMPLE PRE-TEST/POST-TEST FOR MASS

1. A Vitamin C tablet one may take everyday weighs about:

- a. 100 mg
- b. 100 dg
- c. 100 kg
- d. 100 g

2. My 50 cm (about 19") TV weighs approximately:

- a. 936 g
- b. 700 kg
- c. 2368 mg
- d. 25 kg

3. Fill in the blanks:

- a. 2.1 decigram = _____ milligrams
- b. 0.5 kilogram = _____ grams
- c. 1.0 dekagram = _____ decigrams

4. A slice of bread normally would weigh:

- a. 2 g
- b. 20 g
- c. 75 g
- d. 100 g

8.9 Introduction to Temperature

- Rationale - This session is designed to provide the participants with experiences that are related to temperature and the metric system.
- Objectives - Cognitive: Each participant will be able to start and record various temperature using the appropriate language and symbolization.
 - Performance: Each participant will be able to measure the temperature of various materials to the nearest degree Celsius. The student will be able to estimate the temperature of various substances.
- Materials: room thermometers
demonstration thermometer
hot plate
ice or snow
water
pan, various containers
pictures of seasonal activities
- Vocabulary: Celsius
temperature
degree
thermometer
°C
- Evaluation: Pretest Quiz
Post test Quiz
Observation: student measures temperature of objects

STRATEGY FOR SESSION IVA: TEMPERATURE

TOPICS	TIME APPROX.	STRATEGY FOR INSTRUCTION	EVALUATION ASSIGNMENT
• Pre-test	10-15 minutes	• Distribute test; explain purpose and directions; explain use of results, administer test.	Correct, return, use results as beginning point.
• Basic Unit	15-20 minutes	• Distribute station worksheet. Participants will visit various stations and measure and record the temperature of various materials. (See next page for worksheet).	Participants measure and record temp. on worksheet to the nearest degree Celsius.
• Estimation of temp.	15-20 minutes	• Display pictures showing various seasonal activities and foods. Participants will estimate the approximate temperatures of these.	Each poster/picture will have an answer window for participant to check the accuracy of his answer.
• Review concepts and skills taught	15 minutes	• Demonstration, discussion, etc. (For discussions, please refer to the list of objectives and suggested activities contained in the "module on temperature".)	Observation and informal evaluation of participants' answers. For additional classwork or outside assignment, have participants utilize objectives (Primary and/or Intermediate 6.2.2 & 3 to develop materials similar to those contained in module in temperature.
• Post Test	15 minutes	• Post test will evaluate the objectives listed. (Leaders will develop post-test, similar to the pre-test.)	Read preliminary materials for next session. Review concepts, skills, and procedures developed during the workshop.

STATION WORKSHEET - TEMPERATURE

Station A Familiarity with the Celsius Thermometer

Allow participants to become familiar with the Celsius thermometer. They may like to notice the reference points (0°C - freezing point of water, and 100°C boiling point of water). They may like to check the calibration of these points by taking temperature of ice and boiling water.

Station B Practice in Estimation and Measurement of Temperature in degree Celcius.

Let the participants estimate temperature, in degree Celsius, of objects (indoor and outdoor), and then, let them use thermometer to read, and record their temperature in the following table. Let them check how correct their guesses are.

Object	Estimated Temperature	Actual Temperature	Difference
	--- $^{\circ}\text{C}$	--- $^{\circ}\text{C}$	--- $^{\circ}\text{C}$
	--- $^{\circ}\text{C}$	--- $^{\circ}\text{C}$	--- $^{\circ}\text{C}$
	--- $^{\circ}\text{C}$	--- $^{\circ}\text{C}$	--- $^{\circ}\text{C}$

SAMPLE PRE-TEST/POST TEST FOR TEMPERATURE

1. Standard Metric Unit used in measuring temperature is _____.
2. Normal body temperature is _____ degrees Celsius.
3. Water boils at the following temperature:
 - a. 32 °C
 - b. 0 °C
 - c. 100 °C
 - d. 212 °C
4. What is normal room temperature considered to be? _____ °C
5. A comfortable temperature for swimming in a pool would be:
 - a. 75 °C
 - b. 23 °C
 - c. 41 °C
6. Water boils at the following temperature:
 - a. 0 °C
 - b. 212 °C
 - c. 32 °C
 - d. 100 °C
7. Cross-country skiing would be done at a temperature of:
 - a. -10 °C
 - b. 15 °C
 - c. 25 °C

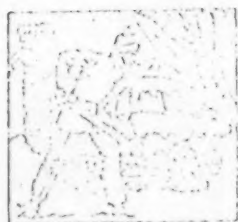
9.0 METRIC AWARENESS COMPONENT
FOR
PARENTS AND OTHER ADULTS

9.0 Metric Awareness Component for Parents and Other Adults

- Each school district will be requested by the Project Director (Advisory Committee) to prepare plans for "Parents Education Nights."
- The Project Director will work closely with the school district authorities to evolve such a plan. The School District Leader will have the major responsibility for the implementation of such a program; leaders at other levels will help.
- In awareness package (length, mass, area, volume, temperature) will be developed for use in the program.
- The "awareness program" will be conducted once a week for 1-1/2 hour duration, for two weeks.
- The "awareness program" will lay heavy emphasis on the "practice" aspect of the metric measurement.
- Awareness workshop brochures are available from the Project Director, (sample is reproduced on the next page.)

TEMPERATURE

degree Celsius



25 DEGREES CELSIUS



25 DEGREES CELSIUS

School District

YOU ARE
INVITED TO ATTEND
THE METRIC WORKSHOP

Place: _____

Date: _____

Day: _____

Time: _____

For further information, please call:

Name: _____

Phone: _____
(Area Code) Number

METRIC EDUCATION

We Are Getting Ready for the Change



1977-78

AWARENESS WORKSHOP

FOR

PARENTS AND OTHER ADULTS
in the Community

REGIONAL PLANNING COUNCIL
Capital Building
1015 Untermyer Boulevard
Albany, New York 12205

Albany-Schenectady-Saratoga REGIONS

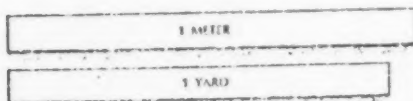
LENGTH

meter

meter a little longer than a
yard (about 10% longer)

kilometer a little longer than half
a mile (5/8 of a mile)

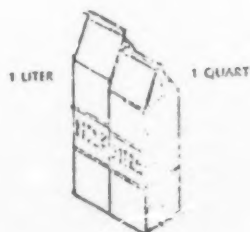
centimeter a little shorter than
half an inch (about 20%
shorter)



VOLUME

liter

liter a little more than a
quart (about 10% more)



(comparative sizes are shown)

MASS

kilogram

gram about the weight of a
paper clip



kilogram a little more than
2 pounds (about 10%
more)



(comparative sizes are shown)

10.0 SCHOOL DISTRICT METRICATION POLICY

10.0 School District Metrication Policy

10.1 A Suggestion: Whereas the introduction of the Metric system is not yet mandatory in our school curriculum, as educators, who are convinced that it should be included, we should work toward local policy development for it. It is strongly suggested that metric education leaders (BOCES level, school district level, school building level) and classroom teachers assume a role of convincing the school authorities for adoption of a policy statement. New York State Education Department has suggested sample guidelines for such a statement which is given below.

10.2 Sample Guidelines for Metrication

IT IS THE POLICY OF _____
school district that:

- the metric system become the principal system of measure in the curriculum of the elementary and secondary schools of the district.
- metric measure be implemented in the schools with the express intention of ensuring that programs of instruction become predominantly metric by September 1980.
- metrication be applicable to all areas of the curriculum and that all measured quantities, wherever appropriate be stated in metric units.
- the units and symbols of the metric system taught in the schools conform to those of the International System of Units, known as SI.
- metric education be accepted as an opportunity to reassess pedagogical approaches of the topic of measurement as a whole; that student be provided with opportunities to acquire a practical and experiential knowledge of metric units through activities that involve comparing, estimating, measuring, and related problem-solving.
- metric changes in the curriculum be coordinated with corresponding changes in industry and commerce.
- metric learning materials in the schools be instituted on a pre-planned and gradual basis with due consideration being given to the attrition, modification, and replacement of materials, as well as to the availability of new learning materials.